TECHNICAL REPORT
70-37-CE

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DEVELOPMENT OF A PERSONAL COOLING SYSTEM FOR EXPLOSIVE ORDNANCE DISPOSAL PERSONNEL

By

Captain Berry Crain, Jr. and Vincent D. Iacono

December 1969

UNITED STATES ARMY
NATICK LABORATORIES
Natick, Massachusetts 01760

Clothing and Personal Life Support Equipment Laboratory
C&PLSEL-69

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DEVELOPMENT OF A PERSONAL COOLING SYSTEM FOR EXPLOSIVE ORDNANCE DISPOSAL PERSONNEL

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FOREWORD

This report describes the development and construction of a prototype personal cooling system consisting of a ventilated undergarment and a battery-powered ventilating backpack. This system, when worn in conjunction with a protective armor system, will enable Explosive Ordnance Disposal Personnel to perform their mission more safely and more comfortably while working in areas under exposure to fragmenting munitions.

The design and engineering of this personal cooling system were performed by the U.S. Army Natick Laboratories for the Limited War Laboratory, Aberdeen Proving Ground, Maryland, under Limited War Laboratory Order #69-41.

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ABSTRACT

The development and construction of a personal cooling system to be used by military personnel engaged in the clearance and disposal of munitions in the field is discussed. The total system consists of an air distribution undergarment and a battery-powered ventilating backpack. The ventilating backpack is designed to provide 18 cfm of ambient air for ventilation of the torso to relieve the heat stress imposed on the individual by the armor clothing worn over the air distribution system. Each charge of the modular rechargeable battery assembly provides adequate power to operate the blower for two hours.

DEVELOPMENT OF A PERSONAL COOLING SYSTEM

FOR EXPLOSIVE ORDNANCE DISPOSAL PERSONNEL

1. Introduction

There is a hazard to personnel exposed to fragmenting munitions encountered in clearing up ammunition supply points which had been subjected to explosions and fire. The feasibility of developing a protective armor system and a lightweight ventilated clothing system to be worn under an armor system were investigated as a possible solution to this problem.

Development of a prototype ventilated undergarment and ventilating backpack to be worn in conjunction with the proposed protective armor system is discussed in this report.

2. Design Requirements

The design requirements for the ventilated undergarment are:

a. The undergarment should be lightweight and unrestrictive to movement.
b. It must be capable of distributing 18 cfm of air over the torso area.

For the ventilating backpack the design requirements are:

a. The backpack should be powered by rechargeable battery packs.
b. The battery packs should be modular and easily exchanged.
c. The unit must be capable of supplying enough air to the ventilated undergarment to relieve the heat stress imposed by the armored clothing worn over the air distribution garment.

3. Design of Ventilated Undergarment

The ventilated undergarment to be worn in conjunction with the protective armor system was developed for Southeast Asia pilots of the OV-1 Mohawk aircraft (Figure 1). The undergarment is designed to remove heat primarily from the torso and groin areas and thus provide relief of the heat stress imposed by the cabin environment of the OV-1 Mohawk aircraft. This undergarment is lighter in weight than undergarments which cover the entire body and is less restrictive to arm and leg movement. The ventilated undergarment weighs 2.3 pounds.

The undergarment is composed of a three-dimensional spacer fabric covered on each side by Lycra stretch fabric. A sectional schematic of the undergarment is shown in Figure 2. The ventilating air flow enters the

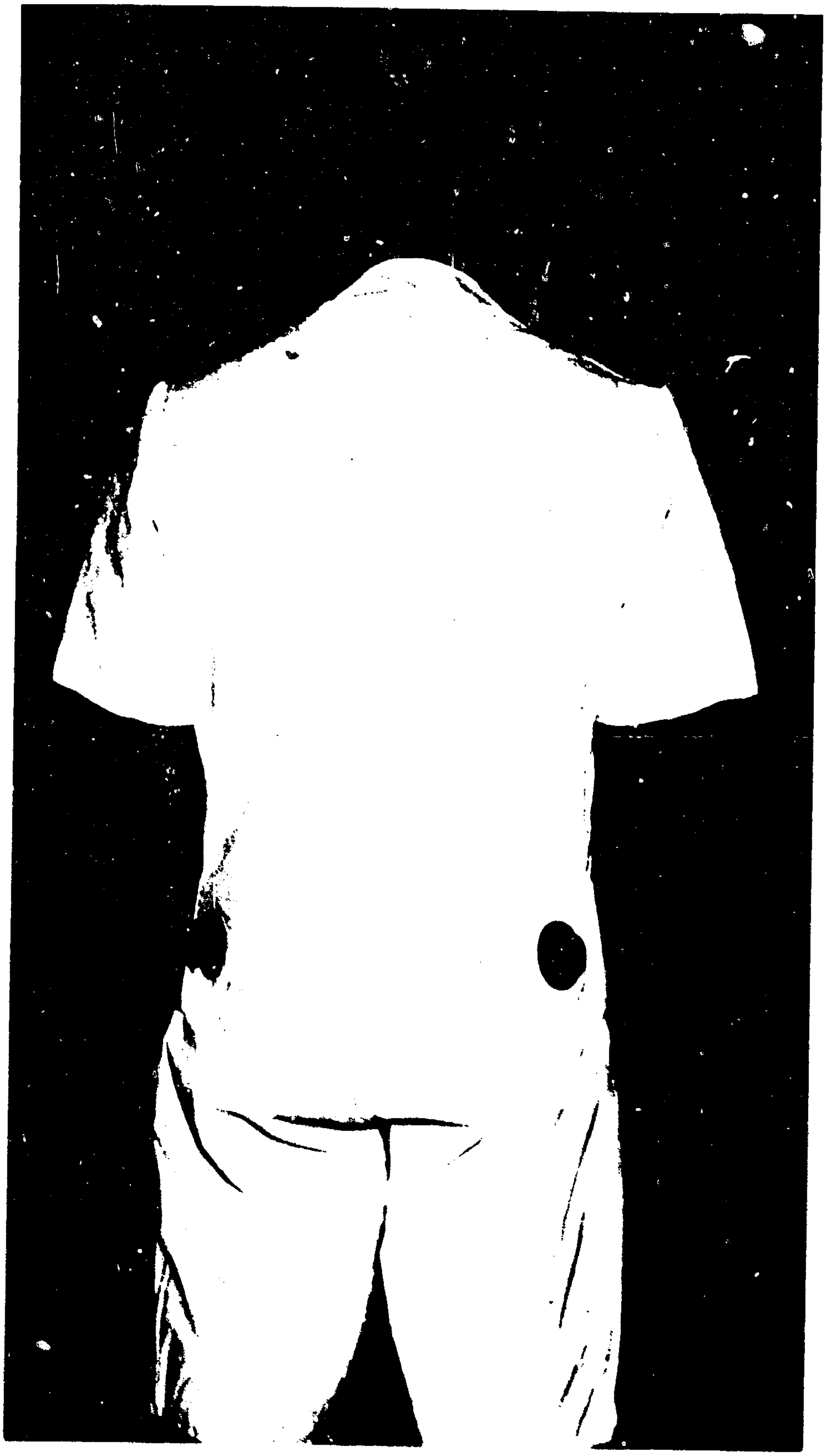


Figure 1. Ventilated Undergarment

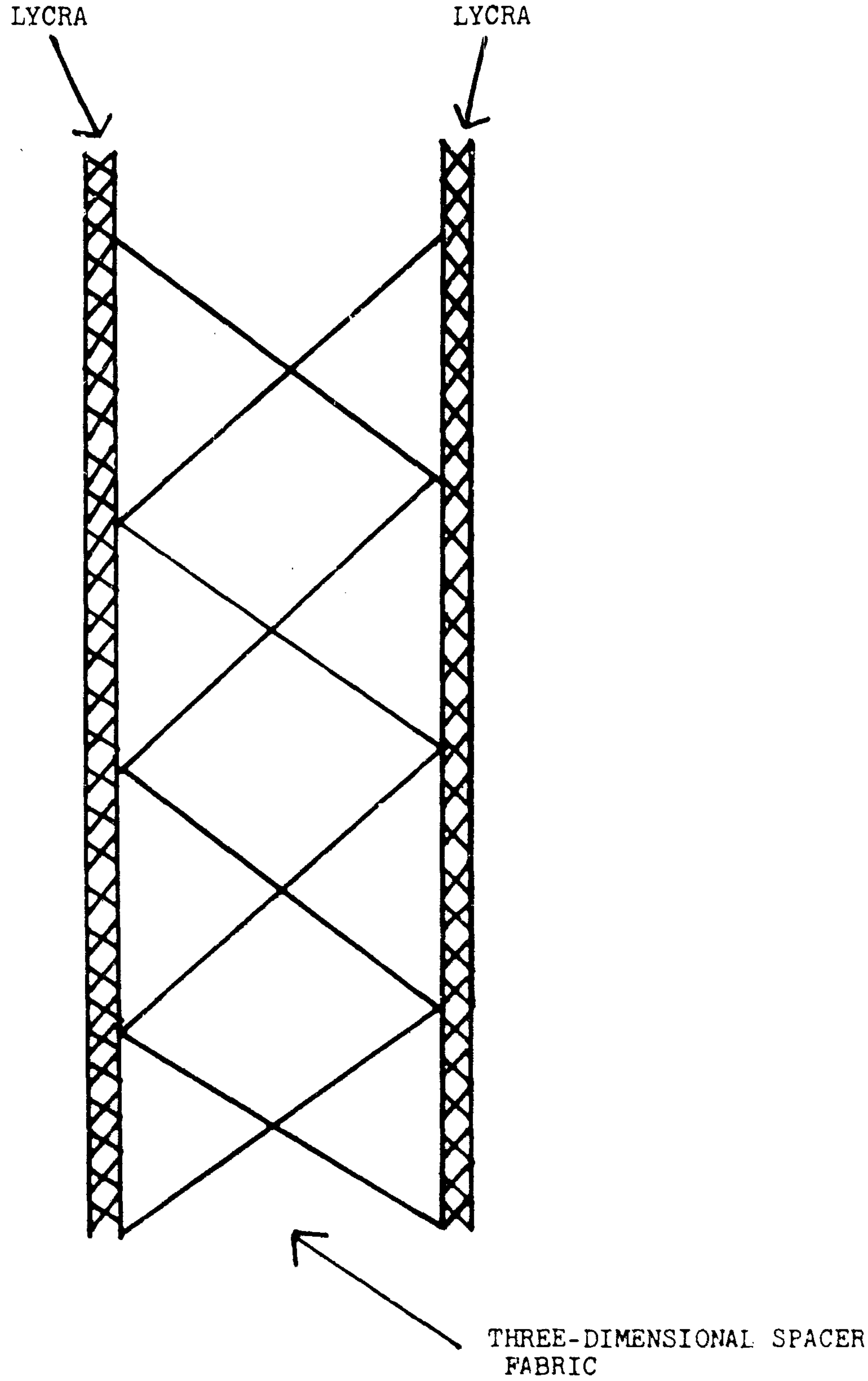


Figure 2. Schematic Diagram of the Ventilated Undergarment

undergarment through two quick disconnect couplings located above the hips and is distributed over the front and back of the torso through an impermeable manifold system. The air flow then disperses throughout the three-dimensional spacer and passes finally to the skin where sensible heat is absorbed by the air through evaporation of perspiration. It should be noted that at ambient conditions higher than skin temperature, body cooling is achieved entirely by evaporation of sweat.

4. Design of Ventilating Backpack

The ventilating backpack is designed to provide the undergarment with a ventilating flow of 18 cfm of ambient air, while keeping size and weight to a minimum. The backpack is approximately 18 inches long and 10 inches wide, with a thickness of about 5 inches. The weight of the backpack with hoses, shoulder harness, and battery pack is slightly over 17 pounds. The backpack and undergarment are shown in Figures 3, 4, 5, and 6. In actuality the ventilated undergarment would be worn under the individual's clothing next to the skin and the backpack would be worn over the protective armor system.

Air is supplied to the undergarment by a centrifugal motor blower unit mounted in the backpack. Ambient air is drawn into the backpack through a series of holes covered with nylon mesh to prevent insects or other objects from being drawn into the blower. The air is expelled from the blower into a manifold which distributes the air evenly between two rubber-lined nylon hoses. The hose ends are provided with male quick-disconnect couplings which can be connected to the undergarment. The motor blower unit operates at 3.0 amps and 12.5 volts and provides 18 cfm at 3.5 inches of water outlet pressure.

The motor blower is powered by a removable battery pack designed for quick and easy exchange. The battery pack supplies a nominal voltage of 12.5 volts and at a discharge rate of 3.0 amps will provide enough power to operate the unit for a two-hour period. The battery pack can be recharged using a power supply by charging at 700 milliamperes for 13 hours.

The outer case of the backpack is vacuum molded from a acrilonitrile-butadiene-styrene plastic in two pieces and is fastened together by the use of a hinged extruded aluminum closure. The thickness of the plastic before molding was 125 mils and after molding is 90-100 mils. The closure is secured with three butterfly fasteners. The internal supports for the motor blower and the battery pack are fabricated from aluminum stock.

5. Approximate Weight Breakdown of Ventilating Backpack

	(lb)
Weight of backpack less harness, hoses, fittings, and batterypack	5
Weight of harness, hoses, and fittings	2
Weight of battery pack	10
Total Weight	17

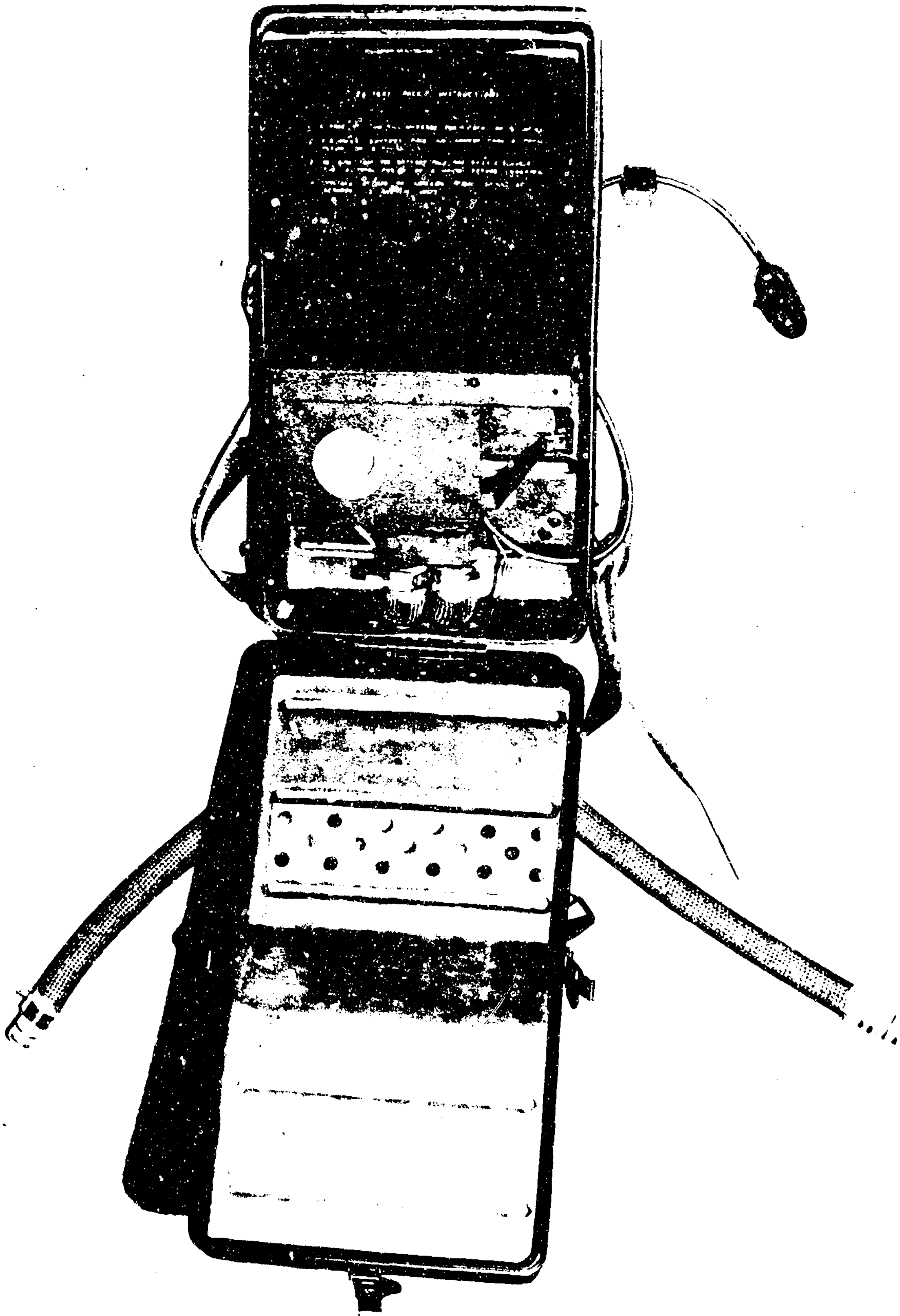
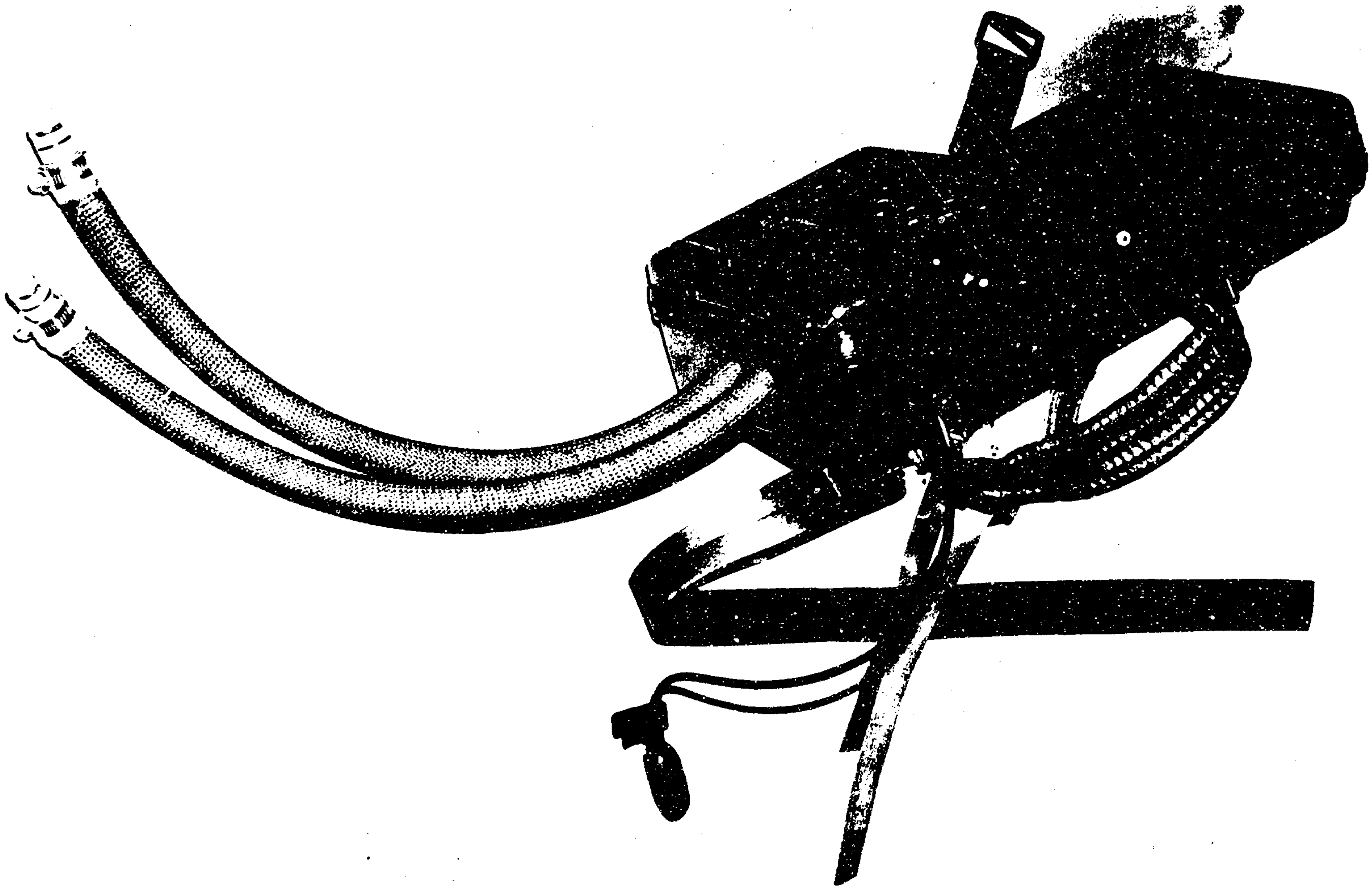


Figure 3. Ventilating Backpack (open)



Fiaure 4. Ventilating Backpack (Closed)

Figure 5. Ventilating Backpack and Ventilated Undergarment (Back View)

Figure 6. Ventilating Backpack and Ventilated Undergarment (Side View)

6. Cost Estimate

Based on the production of 50 sets of ventilated undergarments and ventilating backpacks, the following costs are estimated:

Cost of ventilating garment	$125.00
Cost of ventilating backpack	350.00
Total cost	$475.00

7. Battery Pack Characteristics and Charging Procedure

The battery packs are composed of 10 nickel-cadmium batteries enclosed in a molded ABS case and packed in styrofoam. The batteries are wired in series and connected to the motor blower by a two-piece contact microphone connector. The battery packs are modular and easily exchanged.

The nickel-cadmium batteries used in the battery packs are of rugged construction and require no addition of electrolyte. They can be recharged satisfactorily many times and may stand for long periods of time in either the charged or discharged state without any adverse effects.

The battery packs should be charged at a rate of 700 milliamperes for 13 hours. Charging for a longer period or at a higher rate would be detrimental to the battery life. The voltage of the battery pack at the end of this charging period should be approximately 14 volts. A voltage of less than 13 volts at the end of the charging period would indicate that there may be a dead or weak battery in the battery pack.

Each battery pack should be discharged for a total period of two hours. Damage to the batteries may occur if the packs are discharged for more than two hours or if the packs are charged after having been discharged for less than two hours. Typical discharge curves for the battery packs are shown in Figure 7.

8. Operational Characteristics

Tests were run to determine the operating curves for the blower and for the distribution system. The blower was tested to measure the volume of flow it would produce over a range of outlet static pressures. The distribution garment was tested to determine the pressure drop developed in it over a range of volumetric flows. The operating curves are shown in Figure 8. These data show that the operating point for the combined system will be at about 18 cfm with a pressure drop of about 3.5 inches of water.

The distribution garment is designed to remove heat from the wearer by evaporation of perspiration. The garment distributes ambient air over the body which, as it flows next to the skin, picks up heat and moisture from the body. About 1050 Btu's are removed for every pound of water evaporated. If ambient conditions are not overly warm and humid, e.g., 70-80°F., and less than 50%RH, the wearer can be comfortable in the distribution garment for an indefinite period. If the ambient temperature and humidity are high, the rate of heat removal will decrease. Under these conditions the garment cannot be worn indefinitely but the wearing period will be considerably extended.

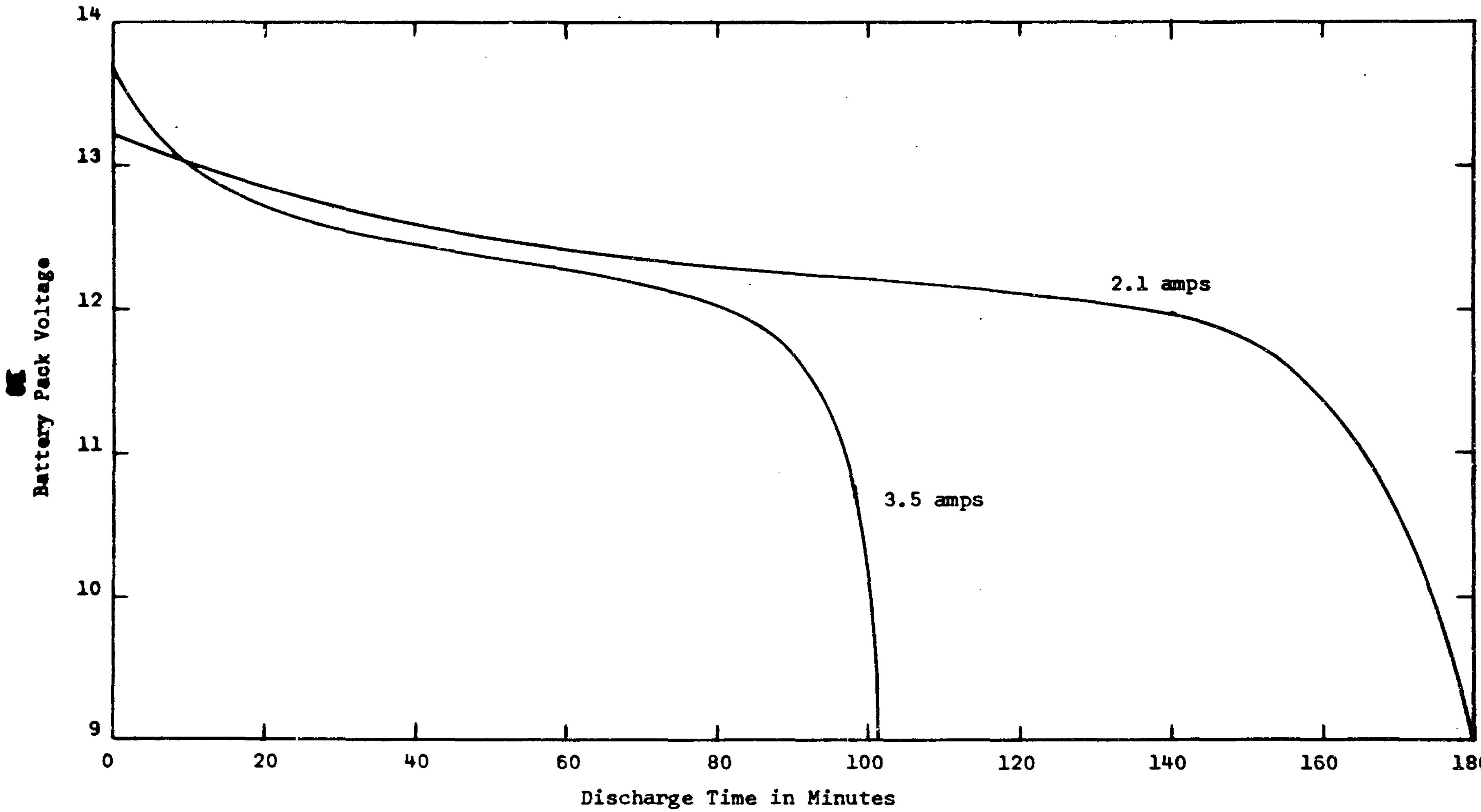


Figure 7. Battery Pack Discharge Curves

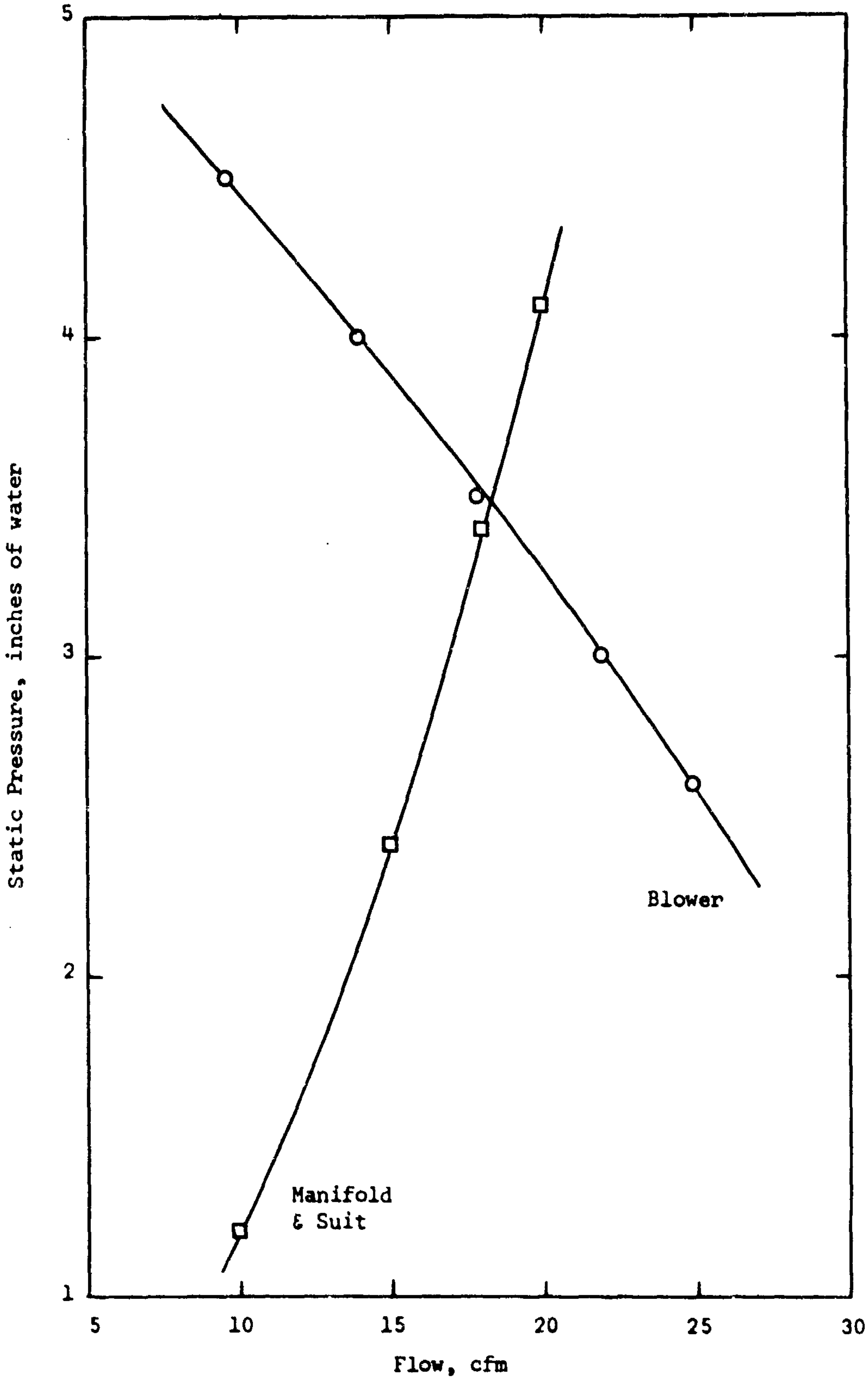


Figure 8. System Operating Curves

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Design	8					
Development	8					
Cooling systems	9		4			
Ventilation	10		8,10			
Underwear	10		9			
Body armor	4		4			
Protective Clotning	4		4			
Clothing systems	4		4			
Packs (carrying)			10			